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A Super-Precise Cutting Technology for Black Metals and Hard-Processing Materials by Diamond

Abstract:

With the development of modern industry, the processing precision required to the black metals and hard processing materials is higher and higher. However, the traditional super-precise cutting processing technology is hard to meet the requirement, moreover, diamond is very expensive. The present invention uses cooling liquor at a lower temperature to protect the diamond lathe tool during the super-precise processing, which can enhance the working life of the diamond lathe tool, so as to bring significant economic benefit, and save a large amount of cost.

Claims

1. A method for super-precisely processing the black metals and hard-processing materials, characterized in that the diamond lathe tool super-precisely processes the black metals and hard-processing materials under the protection of cooling liquor at a lower temperature.

2. The method according to claim 1, characterized in that the cooling liquor is liquid nitrogen (-130℃~-182℃), liquid CO_2 (-50℃~-76℃).

Specification

The present invention relates to field of mechanical production and process.

For a long time, the super-precise cutting of black metals and hard processing materials by diamond is an acknowledged difficult problem. Due to the highly chemical affinity of the diamond and steel, titanium and the like, carbon of the diamond diffuses to surface of the workpiece with a somewhat fast speed during the cutting process, which results in rapid abrasion of the diamond lathe tool. The skilled in the art abroad attempts a cutting method with the protection of a carbon rich gas, the basic theory thereof being the preferred diffusion phenomenon, that is, during the cutting process, compared with the solid diamond, carbon in the gas is more active than that in the diamond, such that it will firstly reacts with the surface of the workpiece, so as to slow down the diffusion of the carbon in diamond, achieving the purpose of protecting the diamond lathe tool. However, due to the tight contact between the rake face of the lathe tool and the cutting layer within the contacting region during the cutting process, the protective gas cannot directly contact with the cutting edge of the lathe tool. Therefore, a complete protection cannot be achieved, and the abrasion of the diamond lathe tool cannot be avoided, that is to say, the method for cutting steel by diamond under the protection of gas cannot put into use successfully.

With the development of modern industry, the processing precision required to the black metals and hard processing materials is higher and higher. However, the traditional super-precise cutting processing technology is har to meet the requirement, moreover, the diamond lathe tool is very expensive, so that if a prolonged working life cannot be assured, a satisfactory processing precision of material cannot be achieved. The purpose of the present invention is thus to prolong the working life of the diamond lathe tool, so as to allow it to be used for super-precisely cutting of black metals and

hard processing materials.

The abrasion mechanism of the diamond lathe tool lies in the high cutting temperature, which is one of the main factors resulting in the abrasion of diamond lathe tool. In view of controlling the cutting temperature, a liquor at a low temperature is used as the cooling liquor, for cooling the diamond lathe tool and the workpiece, so as to inhibit the abrasion of lathe tool, allowing the successful conduction of cutting. In the present invention, liquid nitrogen (-130~-182℃) and liquid CO_2 (-50~-76℃) is used as cooling liquors which are drived by compressed air, compressed air is employed as force; wherein the liquid nitrogen is pumped from a special vessel (Dewar's flask), and is directly poured into the cutting region via a nozzle. In order to ensure a certain dimension precision, the shrink problem of the steel at lower temperatures should be further solved. This can be solved by trial and error for predicting the shrinkage, so as to determine the degree of cutting. Due to the relative movement between the lathe tool and the workpiece during the cutting process, the problem concerning the cooling effect should be additionally solved. In order to ensure sufficient cooling and decrease the cutting temperature, the present invention employs two means of: (1) firstly pre-cooling the workpiece, i.e. immersing the workpiece in the liquid nitrogen, and then maintaining the temperature within the cutting region lower than 600 ℃ utilizing the temperature gradient; (2) using a low temperature liquor under super large flow. Since the cutting depth by the diamond is relatively shallow, when the amount of cooling liquor is enough to reduce the heat in the cutting region by timely heat exchange among the workpiece, the lathe tool and the cutting scraps, so as to ensure the cutting temperature being limited within a certain range. This is because there is a critical temperature when the diamond lathe tool is abraded, and if the cutting temperature is not controlled to be below the critical temperature, the abrasion of the lathe tool cannot be effectively controlled. This is the key of the present invention.

The present invention can improve the working life of the diamond lathe tool, such that the economic benefit is very significant. According to the currently domestic price, a diamond lathe tool of grade 1 with about 1.5 carats is 2,600 RMB. If the working life is enhanced ten times; about more than twenty thousand RMB can be saved. Hundreds of diamond lathe tool are consumed per year domestically, such that more than 1 million RMB can be totally saved. More importantly, the employment of present invention allows the super-precise cutting of black metals and hard processing materials which cannot be achieved in the past at all.

Examples:

The steel was cut at a super-low temperature. The workpiece used was 45# steel, under normalized status. The workpiece had a diameter of Φ50 mm. The machine tool used was S1-25S highly-precise lathe, with a rotate speed of n=200n/min, a feed S=0.5/min, and a depth of lathe T=1~10μ m. The lathe tool used was a natural diamond lathe tool with monocrystal. The comparison on working life was: by cutting at a normal temperature for 1 minute, the abrasion of the lathe tool reached 0.01 mm, and the surface precision was significantly degraded, resulting in that the cutting could not be conducted; whilst during the cutting with the present process for 10-20 minutes, the finish degree of the cutting surface did not varied significantly, and no abrasion of the lathe tool was observed by a normal microscope. The comparison meant the cutting procedure with the present process was stable, the working life of the lathe tool was enhanced by ten to twenty times which was sufficient to keep the successful conduction of the cutting, and the processing precision could be controlled to be 0.005 mm as well as the surface roughness to be 0.04 μ m.

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[54]发明名称 黑金属及难加工材料的金刚石超精密切削工艺

[57]摘要

由于现代工业的发展，对黑色金属及难加工材料的加工精度要求越来越高，使用传统的超精密切削工艺已难以实现，而且金刚石的价格昂贵，本发明采用低温冷却液保护金刚石车刀进行超精细加工，可提高金刚石车刀的寿命，从而得到明显的经济效益，节约大量资金。

1、黑色金属及难加工材料的金刚石超精加工方法。本发明的特征在于金刚石车刀在低温冷却液保护下对黑色金属及难加工材料进行超精细加工工艺。

2。如权利要求1所述：其特征在于冷却液为液氮（-130℃-182℃），液体CO_2（-50℃-76℃）。

黑金属及难加工材料的金刚石超精切削工艺

本发明属于机械制造及加工领域。

长期以来，黑色金属及难加工材料的金刚石超精密切削一直是大家公认的难题。由于金刚石和钢、钛等金属的化学亲和力较强，在切削过程中金刚石的碳向工件表面扩散的较快，因此造成了金刚石车刀的急剧磨损。国外有人试验了富碳气体保护法切削，其基本原理是优先扩散现象，即在切削过程中，和固体金刚石相比，气体中的碳比金刚石的碳更活泼，会首先和工件表面发生反应，以减缓金刚石中碳的扩散，从而达到保护金刚石刀具的目的。但是由于在切削过程中，刀具前刀面和切削层在切削区接触致密，保护气体不能和刀具刃口完全直接接触，因此也就不能完全起到保护作用，还是不可避免地要造成金刚石刀具的磨损，所以气体保护法金刚石切削钢还不能达到应用。〔1〕〔2〕

现代工业的发展，对黑色金属及难加工材料要求加工精度越来越高，但使用传统的超精密切削加工艺难以实现，金刚石刀具价格昂贵，如不能保证其使用寿命，就不能解决材料的加工精度，本发明的目的是提高金刚石刀具的使用寿命，使之可用于黑色金属及难加工材料的超精切削。

金刚石车刀的磨损机理是由于切削温度高，是导致金刚石车刀磨损主要因素之一。从控制切削温度出发，采用了低温液体做为冷却液，来冷却金刚石刀具及工件，从而抑制刀具磨损。使切削可顺

利进行。本发明采用液氮（-130——$-182^{\circ}C$），液体CO_2（-50——$-76^{\circ}C$）为冷却液，利用压缩空气为动力，将液氮从专门的容器（杜瓦瓶）内抽压出来，经过一个喷嘴，直接浇在切削区内。为了保证一定的尺寸精度，还需解决钢的低温收缩问题，这可通过多次重复试验，用预测其收缩量，从而确定切削量。由于切削过程中刀具和工件的相对运动，还应解决冷却效果的问题，为了保证冷却充分，降低切削温度，本发明采用了两个措施：（1）先对工件进行预冷，即将工件浸泡在液氮中，然后利用其温度梯度，保证切削区温度低于600℃，（2）采用超大流量的低温液体致冷。因为金刚石切削切深较小，当冷却液足够充分时，切削区的热量可通过工件刀具与切屑的及时换热被减少，从而保证切削温度被限制在一定范围，这是因为金刚石车刀在磨损时存在一个临界温度，如果不把切削温度控制在临界温度以下，则不能有效的控制刀具磨损，这是本发明的关键。

本发明可提高金刚石刀具的寿命，其经济效益十分明显，根据国家现行价格，一把一级1。5克拉左右的金刚石车刀2，600元，如提高寿命十倍，就可节约两万余元，全国每年金刚石车刀需要数百把，共节约价值可超过百万元。更为重要的是应用本方法可进行过去根本无法实现的黑色金属及难加工材料的超精密切削。

实施例：

超低温切削钢，工件材料45#钢，正火状态，工件直径ø50 mm，机床S1-25S高精度车床，转速n=200n/min，走刀量S=0。5/min，吃刀深度T=1～10μm，刀具：天然金刚石单晶车刀。寿命比较：常温切削1分钟刀具磨损量达0．01mm，加工

表面精度明显变坏，使得切削无法进行，采用本工艺在达10–20分钟的切削中，切削表面光洁度无明显变化，用普通的显微镜难以观察到刀具的磨损，切削过程稳定，刀具寿命提高10–20倍，足以维持切削的顺利进行，其加工精度可控制0.005mm，表面粗糙度为0.04μm。